NATIONAL BUREAU OF STANDARDS REPORT

5427

PROGRESS REPORT FOR QUARTER ENDING JUNE 30, 1957

on

REFRIGERATION AND FIELD EQUIPMENT

by

C. W. Phillips
P. R. Achenbach

Report to
Quartermaster Research and Engineering Command
Department of the Army
Natick, Massachusetts

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

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The functions of the National Bureau of Standards are set forth in the Act of Congress, March 3, 1901, as amended by Congress in Public Law 619, 1950. These include the development and maintenance of the national standards of measurement and the provision of means and methods for making measurements consistent with these standards; the determination of physical constants and properties of materials; the development of methods and instruments for testing materials, devices, and structures; advisory services to Government Agencies on scientific and technical problems; invention and development of devices to serve special needs of the Government; and the development of standard practices, codes, and specifications. The work includes basic and applied research, development, engineering, instrumentation, testing, evaluation, calibration services, and various consultation and information services. A major portion of the Bureau's work is performed for other Government Agencies, particularly the Department of Defense and the Atomic Energy Commission. The scope of activities is suggested by the listing of divisions and sections on the inside of the back cover.

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The results of the Bureau's work take the form of either actual equipment and devices or published papers and reports. Reports are issued to the sponsoring agency of a particular project or program. Published papers appear either in the Bureau's own series of publications or in the journals of professional and scientific societies. The Bureau itself publishes three monthly periodicals, available from the Government Printing Office: The Journal of Research, which presents complete papers reporting technical investigations; the Technical News Bulletin, which presents summary and preliminary reports on work in progress; and Basic Radio Propagation Predictions, which provides data for determining the best frequencies to use for radio communications throughout the world. There are also five series of nonperiodical publications: The Applied Mathematics Series, Circulars, Handbooks, Building Materials and Structures Reports, and Miscellaneous Publications.

Information on the Bureau's publications can be found in NBS Circular 460, Publications of the National Bureau of Standards ($1.25) and its Supplement ($0.75), available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

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C. W. Phillips and P. R. Achenbach
Air Conditioning, Heating, and Refrigeration Section
Building Technology Division

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Introduction

The projects reported are limited to those carried on under Order No. 57-21 and include the gas engine exhaust-to-refrigerant heat exchanger, two Kentucky trailers, study of refrigerated structures, metering heat sink, and the refrigerator specification. The work done on the Kentucky trailers, refrigerated structure study, and metering heat sink is discussed under the project title "Metering Heat Sink for Refrigerated Structures." A project cost breakdown is included at the end of the report.

Exhaust Gas -to-Refrigerant Heat Exchanger

Modification of the test setup for this important study to permit determination of the heating ability of a standard one-ton refrigerating unit equipped with the NBS prototype exhaust gas-to-refrigerant heat exchanger was continued during this quarter. The study has been renewed after being dormant for about two years. The modification, which is about 90% complete, is intended to provide test conditions of minus 40F on the condenser side and 35F on the evaporator side of the unit with the prototype heat exchanger. Temperatures on the condenser side below minus 20F were not possible previously. The original liquid-cooled Crosley engine has been replaced by a model VE4 Wisconsin air-cooled engine, equipped with an external electric motor for cranking at the low temperature. Failure of the engine to crank and start readily at low temperatures was a primary source of test difficulty in the previous tests. The prototype heat exchanger has been equipped with improved headers to facilitate rodding of the exhaust gas tubes which is necessary at regular intervals.

Metering Heat Sink for Refrigerated Structures

Reference is made to NBS Report No. 5283, Progress Report for Quarter Ending April 6, 1957, submitted to Quartermaster Research and Engineering Command under date

of May 14, which includes part of the work actually done during the quarter currently being reported (ending June 30, 1957) in connection with the metering heat sink. On pages 3 and 4 of Report No.5283, "April 1" should be corrected to read "May 1."

As discussed in Report No. 5283, a Kentucky Mod. No. M-349 21-foot insulated semitrailer (Ser.No. 18060, NBS No. 127-56) was used for the tests with the metering heat sink. On March 28 the insulated spaces in the trailer walls, ceiling, and floor had been inspected, following which the inspection openings were patched with metal plates. About 45 holes, some three-inch and some four-inch, were drilled in the trailer exterior at various locations: ten in the roof; ten on each side wall, five near the top and five near the lower edge; four on each end, two near the top and two near the lower edge; seven in the bottom.

Without allowing any of the ice in the walls to melt, the test was continued at conditions of 0F trailer temperature and 110F ambient temperature at 60 percent relative humidity. The rate of frost and ice gain (by weight) was about 1.3 pounds per hour, as compared to about 1.2 pounds per hour at the start of the first test without any holes cut in the exterior, and as compared with about 0.7 pound per hour just before the March 28 inspection when 850 pounds of frost and ice had been accumulated in the insulating space.

The test was continued until about May 1, when the inspection patches were removed and the ice accumulation again observed. About 500 pounds more ice had accumulated in the insulated space, and the heat transfer rate with an ambient humidity of 60% had started to increase at a sharper rate, the rate being about 90Btu per hour (°F) by May 1. Before the walls were opened for inspection, the humidity in the test room was lowered to 15% and a check of the heat transfer rate with the additional 500 pounds of ice, and at the lower humidity, was made. These data have not yet been analyzed, but appear to show the same decrease as for the previous tests when nothing other than the humidity was changed.

The significant comparison between the two phases is the little change in the rate of weight gain with no holes cut in the exterior and with many holes cut in the exterior. Careful examination of the vehicle body shows a few openings in the bottom exterior at the corners. Drops of water had been observed prior to this series of tests emerging around rivet heads and coming through seams, etc., when the exterior skin had been

cooled suddenly, permitting condensation to form on the inside of the exterior skin.

The examination of the walls on May 1 showed little increase of ice or frost in or at the floor or at the lower edge of the walls. There was some increase in the amount of frost at the top edge of the walls and a great increase in the frost along the center of the top, being heaviest at or near the holes cut into the top exterior surface. Photos of these areas were made and will be included in the project report.

Following the examination of the insulated spaces on May 1, the trailer interior was heated to a temperature of 135F and the ambient temperature was lowered to 35F for defrosting. Approximately two days were required for the trailer interior to reach 135F under these conditions with an internal electric heating supply of about 7200 Btu/hr. During this two-day period about 1000 lbs. of ice melted and the water drained from many openings (under rivet heads, at seams, etc.) in the trailer exterior.

For the next fifteen days conditions were maintained at 135F trailer interior temperature and 35F ambient temperature. The trailer continued to lose weight and was still dripping at the conclusion of this period. The weight reduction during the fifteen days was about 225 lbs , an average of 15 lbs per day, and the apparent heat transfer rate dropped from 117 Btu/hr (°F) to 78 Btu/hr. (°F) during the same period. In the last twenty-four hours of the test six pounds of water were driven from the insulated spaces of the trailer. If it is assumed that this water was evaporated, the observed heat transfer rate of 78 Btu/hr (°F), can be corrected to eliminate the effect of evaporating six pounds of water per 24 hours. The resulting heat transfer rate would be 75 Btu/hr (°F), as compared weth an observed initial heat transfer rate of about 68 Btu/hr (°F) before the trailer was subjected to the ice accumulation test.

About 200 lbs of water remained in the insulation when this test was arbitrarily concluded. Examination showed that the insulation at the center of the roof was still very wet, becoming less wet near the edges of the roof, indicating that the water vapor was moving to the inside of the cold exterior skin where it condensed and drained out of openings at the lower edge of the trailer walls. The data from this test are being studied for more detailed reporting.

Following the defrosting period, the trailer was again refrigerated using the prototype metering heat sink to determine the effect on the heat transfer rate and the rate of water pickup caused by sealing certain obvious openings in the bottom exterior skin of the trailer. These tests were concluded at the end of this quarter and the data will be analyzed and reported on in the next progress report.

The metering heat sink was modified during this quarter by substituting more suitable flooded chillers for the methylene chloride brine in place of the previous combination of chillers. Photos have been taken and will be included in the final report on this task.

A search is in progress for a more suitable brine than methylene chloride, and for better materials for flexible brine lines.

During the next quarter air infiltration tests will be made both with the Kentucky trailer used for the ice-accumulation tests and also with a second Kentucky trailer (Mod. No. M349 Ser. No. 18029, NBS No. 124-56) similar to the first but which has not had holes cut in the exterior skin for examination of the insulated spaces.

One conference between representatives of the Air Conditioning, Heating, and Refrigeration Section, NBS, and of QMR & EC was held at Natick on April 9 and several conferences were held at NBS during the quarter, dealing largely with one or more of these projects.

Refrigerator Specification

Preparation of facilities for testing domestic refrigerators was completed and tests of the first of four domestic refrigerators were commenced during this quarter. In compliance with a QMR & E directive dated March 13 (QMRDO-M) four current model domestic electric refrigerators offered as type 1 refrigerators under the classification in interim Federal Specification AA-R-002lld were procured from civilian retail sources as required. This involved preparation of a written justification for a "No-Bid" purchase to avoid disclosure of the purchaser. These refrigerators were picked up by NBS personnel on April 3, thus assuring that they were furnished through regular trade channels. No disclosure of their intended use was made to any supplier. The four makes purchased were:

Frigidaire (Model S-124-57)
Admiral (Model DA1360)
Westinghouse (Model SK-115)
Coldspot (Model L12-A)

The purpose of the requested tests was twofold: first, to determine if the interim Federal Specification AA-R-00211d, would permit selection of commercially-produced refrigerators of adequate quality; and second, to determine the cost and time requirements for making the tests in the subject specification.

The test room and its temperature and humidity controlling equipment were about one-third finished at the beginning of this quarter. The refrigerating system (two 5-ton compressors, one air handler and related equipment), the control system (one circular chart recorder, one proportioning relay, motorized step controller, starters and solenoid valves) and the humidification setup were installed by June 15. There was some delay during this period due to inability to obtain certain necessary repair parts although all major items were on hand.

On June 17 the first test runs with the Frigidaire were started. The tests described in the interim Federal Specification were continued in succession until July 3 when it was found that the refrigerator under test failed to reduce the general food storage compartment temperature below 43F at 110F ambient temperature. Since the refrigerator under test was a type 1 unit, this raised the question of whether the evaporator (chiller) compartment should have been loaded with simulated frozen food for the capacity tests. The frozen food was removed from the chiller and the complete series of tests was started over.

It is expected that the performance tests of the four refrigerators can be completed within the next reporting quarter.

A conference was held at NBS in June 1957, between Mr. Paul Vogel, of QMR & EC, Mr. Frank W. Reinhart, Chief, Organic Plastics Section, NBS, and Mr. W. F. Goddard and Mr. C. W. Phillips, Air Conditioning, Heating, and Refrigeration Section, NBS, to clarify questions posed by industry relative to the plastics requirements of the subject specifications.

Project Cost Breakdown

The project costs for this reporting quarter are given in the accompanying invoice prepared by the Accounting Division. The itemized figures listed herein are the approximate expenditures for the five main items under investigation during the quarter.

Cost Breakdown by Object

Labor	$ 8095
Material	1325
Equipment	492
Misc. Services*	1367
Bureau Supervision	2348
Total	$13627

*Travel, Shipping, Communications, Photos., etc.

Cost Breakdown by Project

Project	Percent of Total Cost
Exhaust Gas Heat-Exchanger	20%
Kentucky Trailers Refrigerated Structures Metering Heat Sink	60%
Refrigerator Specification	20%

At the close of Fiscal Year 1957 approximately $6000 remained on hand under Order 57-21, subject to about $400 of unliquidated obligations.

U. S. DEPARTMENT OF COMMERCE
Sinclair Weeks, *Secretary*

NATIONAL BUREAU OF STANDARDS
A. V. Astin, *Director*

THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its headquarters in Washington, D. C., and its major field laboratories in Boulder, Colorado, is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant reports and publications, appears on the inside front cover of this report.

WASHINGTON, D. C.

Electricity and Electronics. Resistance and Reactance. Electron Tubes. Electrical Instruments. Magnetic Measurements. Dielectrics. Engineering Electronics. Electronic Instrumentation. Electrochemistry.

Optics and Metrology. Photometry and Colorimetry. Optical Instruments. Photographic Technology. Length. Engineering Metrology.

Heat and Power. Temperature Physics. Thermodynamics. Cryogenic Physics. Rheology and Lubrication. Engine Fuels.

Atomic and Radiation Physics. Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics. Nuclear Physics. Radioactivity. X-rays. Betatron. Nucleonic Instrumentation. Radiological Equipment. AEC Radiation Instruments.

Chemistry. Organic Coatings. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Gas Chemistry. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

Mechanics. Sound. Mechanical Instruments. Fluid Mechanics. Engineering Mechanics. Mass and Scale. Capacity, Density, and Fluid Meters. Combustion Controls.

Organic and Fibrous Materials. Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Organic Plastics. Dental Research.

Metallurgy. Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion. Metal Physics.

Mineral Products. Engineering Ceramics. Glass. Refractories. Enameled Metals. Concreting Materials. Constitution and Microstructure.

Building Technology. Structural Engineering. Fire Protection. Heating and Air Conditioning. Floor, Roof, and Wall Coverings. Codes and Specifications.

Applied Mathematics. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics.

Data Processing Systems. SEAC Engineering Group. Components and Techniques. Digital Circuitry. Digital Systems. Analogue Systems. Application Engineering.

• Office of Basic Instrumentation

• Office of Weights and Measures

BOULDER, COLORADO

Cryogenic Engineering. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Gas Liquefaction.

Radio Propagation Physics. Upper Atmosphere Research. Ionospheric Research. Regular Propagation Services. Sun-Earth Relationships.

Radio Propagation Engineering. Data Reduction Instrumentation. Modulation Systems. Navigation Systems. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Radio Systems Application Engineering.

Radio Standards. Radio Frequencies. Microwave Frequencies. High Frequency Electrical Standards. Radio Broadcast Service. High Frequency Impedance Standards. Calibration Center. Microwave Physics. Microwave Circuit Standards.


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